Diversity of chigger mites on small mammals in the surrounding areas of Erhai Lake in Yunnan, China

DONG Wen-Ge[1], GUO Xian-Guo[1,*], MEN Xing-Yuan[2], QIAN Ti-Jun[1], WU Dian[1]

(1. Institute of Pathogens and Vectors, Dali University, Dali, Yunnan 671000, China;
2. Institute of Plant Protection, Shandong Academy of Agricultural Sciences, Jinan 250100, China)

Abstract: The aim of the present study was to study the species diversity, community structure, similarity, distribution and niche of chigger mites on the body surface of 3 303 small mammals in the surrounding areas of Erhai Lake in Dali, Yunnan by using Shannon-Wiener, hierarchical cluster analysis (SPSS 13.0) and Levins' niche. The investigated site was located in the wild rodent-type plague focus, one of 11 known plague foci in China and also an important focus of both tsutsugamushi disease and epidemic hemorrhagic fever (EHF), where stand alongside three cordilleras surrounding the Erhai Lake, namely Eastern Wuliang Mountain, Southern Ailao Mountain and Western Cangshan Mountain. The three confined oriented areas with different landscapes are within the same zone with similar longitude, latitude, altitude and zoological location, which forms an inartificial barrier's isolation by Erhai Lake. A total of 3 303 small mammal hosts were captured from the three differently oriented areas belonging to 7 families, 15 genera and 21 species in 4 orders (Rodentia, Insectivora, Scandentia and Carnivora), 56 895 individuals of chigger mites collected from the body surface of the small mammal hosts were identified as 3 subfamilies, 13 genera and 109 species. The abundance, distribution and diversity of chigger mites vary among different populations of host species and habitats. Chigger mites spent a considerable time off hosts (only the larvae are ectoparasites) and so are strongly affected by the off-host environment (temperature, precipitation and habitat). Host-specificity of chigger mites is very low, the similarity of chigger mite communities is not highly consistent with the affinity of small mammal hosts in taxonomy and this implies that the co-evolution between small mammals and chigger mites has not reached a high degree, and the above ecological characteristics of chigger mites might strengthen the chigger mites' potential ability of transmitting some mites born diseases among different small mammal hosts.

Key words: Acari; chigger mite; small mammal; different landscapes within the same zone; community ecology; co-evolution; Yunnan

1 INTRODUCTION

Chiggers (chigger mites, trombiculid mites or sand mites) are severe pests in many regions of the world and are important vectors of diseases in a large area of the Far East. Chiggers are a large group of arthropods with about 3 000 species described worldwide to date and more than 400 of which occur in China. These mites have a complex life cycle with seven stages (eggs, pre-larvae, larvae, nymphochrysalis, nymphs, imagochrysalis and adults), but only the larvae are ectoparasites (Li, 1997). Although chigger larvae attack a wide range of hosts, including mammals, birds, reptiles and even some arthropods, and small mammals (especially rodents) are most often parasitized. The hosts' ears are the most common sites of chigger attachment, though they may be found wherever the skin is thin (*e.g.*, anus, nasal cavity and groin). Chiggers that parasitize small mammals are of medical importance because some of them are capable of transmitting tsutsugamushi disease (scrub typhus), while, in recent years, others have been proved to be potential vectors of epidemic hemorrhagic fever (EHF) (Wu *et al.*, 1996, 2004; Li, 1997; Guo *et al.*, 2006).

A great deal of researches on chigger mites of medical importance have been conducted all over the world, and numerous reports described field investigations of their ecology (*e.g.*, Saxena, 1989; Durden, 1992; Pung *et al.*, 1994; Guo *et al.*, 2002; Liu *et al.*, 2004; Hou *et al.*, 2006). In China, Dali of Yunnan Province is an important focus of both tsutsugamushi disease and EHF. Small mammal is

基金项目: 国家自然科学基金项目 (30460125)
作者简介: 董文鸽, 女, 1976 年 12 月生, 硕士, 目前从事媒介生物学研究, E-mail: dongwenge2740@sina.com.cn
* 通讯作者 Author for correspondence, E-mail: xgguo2002@yahoo.com.cn
收稿日期 Received: 2008-07-16; 接受日期 Accepted: 2008-10-23

a very important infectious source of tsutsugamushi disease and epidemic hemorrhagic fever. Chigger mites have been regarded as an important category of medical arthropods with complicated ecological behaviors. Many experts made a great contribution to studying the disease transmission, taxonomy and ecology of chigger mites.

Based on the field investigation in the surrounding areas of Erhai Lake in Dali, Yunnan from 2003 to 2004, this paper studied the species diversity, abundance, community structure, similarity, distribution and ecological niche of chigger mites in the surrounding areas of Erhai Lake in Dali of Yunnan, China. The study is an attempt to illustrate the distribution and associated ecological phenomena (species diversity, abundance, community structure, similarity and ecological niche) of chigger mites in different landscapes within the same geographical zone where the longitude, latitude and altitude are very similar.

2 MATERIALS AND METHODS

2.1 Investigation sites

The investigation of chigger mites on the body surface of small mammals was carried out in the areas of Erhai Lake in Yunnan from 2003 to 2004 (Dong *et al.*, 2008). The survey was made in four kinds of habitats (indoor habitats, cultivated fields, shrub areas and forest) in each of the three differently oriented areas of Erhai Lake (99°58′ – 100°27′ E, 25°25′ – 25°58′ N). At 1 950 – 2 050 m above sea level, the average annual temperature is 15.1℃, the average precipitation is 1 100 mm, and the total area is 400 km^2. The three confined investigation sites have different temperatures and precipitations (Table 1).

Table 1 Average annual temperature and precipitation at the east site (E), west site (W) and south site (S) surrounding Erhai Lake (1976 – 2006)

Site	Temperature (℃)	Precipitation (mm)
E	15.1	890
W	15.0	1 218
S	15.2	1 192

2.2 Collection and identification

Small mammal hosts were randomly captured with cage-traps (10 cm × 12 cm × 18 cm). All the specimens of chigger mites on the body surface of each host were identified under a microscope after drying process (Li, 1997; Liu *et al.*, 2004; Guo *et al.*, 2006; Men *et al.*, 2007; Dong *et al.*, 2008).

2.3 Statistical analysis

2.3.1 Measurement of community structure: The ectoparasitic chigger mite species on the body surface of a certain species of small mammal are regarded as a community of mites. On the basis of defining the communities, the constituent ratio (*Cr*), chigger mite infected rate (*Rm*) and chigger mite index (*Im*) together with the total chigger mite infected rate(*Rmt*) and total chigger mite index (*Imt*), in every chigger mite community, are statistically calculated (Guo *et al.*, 2000). The measurement of community structure includes four basic parameters: species richness(*S*), the diversity index (*H′*), evenness (*J′*) and dominance index (*C′*). The diversity index and evenness are based on Shannon-Wiener's method. The four basic parameters of every mite community are calculated as the following formulae (Guo, 1999; Guo *et al.*, 2000; Gao *et al.*, 2004; Dong *et al.*, 2008).

2.3.2 Calculation of similarity: On the basis of hierarchical cluster analysis, a 19 × 60 primary matrix for the calculation of similarity was formed by 19 dominant community units (19 species of small mammal hosts) and 60 classification variables including 27 chigger mite constituent ratios (*Cr*), 27 chigger mite indices (*Im*), 1 total chigger mite index (*Imt*), 1 total chigger mite infected rate (*Rmt*) and 4 community parameters: richness (*S*), diversity index (*H′*), evenness (*J′*) and dominance index (*C′*). 19 community units and 48 classification variables form a 19 × 60 primary matrix. On the basis of standardizing the primary matrix, hierarchical clustering analysis based on the Pearson correlation coefficient for the nearest neighbor clustering method was used to compared the similarity between every two classification cases (small mammal hosts); the Pearson correlation coefficient was used as the similarity measurement. All the calculations for hierarchical cluster analysis were carried out with SPSS 13.0 (Guo *et al.*, 1996, 1999, 2000, 2004; Lu *et al.*, 2006; Luo *et al.*, 2007; Dong *et al.*, 2008).

2.3.3 Niche breadth: To make a further understanding of coevolution between chigger mites and their small mammals hosts, The Levins' niche breadth in this paper has been modified as the following in order to satisfy the actual needs (Weider, 1993; Guo *et al.*, 1999; Dong *et al.*, 2008).

3 RESULTS

3.1 Species diversity and community structure of chigger mites

Data in Table 2 showed that the species richness (*S*) of chigger mites (109) is much greater in number than the species of their hosts (21), and most small

mammals have two or more species of chigger mites on their body surface. The diversity index (H') of most communities of mites is greater than 1, the diversity indices for Rattus steini and Apodemus chevrieri were 2.5852 and 2.5725, respectively. In addition, evenness (J'), dominance index (C'), the total gamasid mite infected rate (*Rmt*) and total chigger mite index (*Imt*) were also high. The results show that chigger mites on the body surface of these small mammals is high in species richness, with a high diversity indices, while the community structure of chigger mites is very diverse.

3.2 Collection and distribution of small mammal hosts and chigger mites in different landscapes within the same zone

A total of 3 303 individuals of small mammals were captured and identified as 7 families, 15 genera and 21 species in 4 orders (Rodentia, Insectivora, Scandentia and Carnivora). Most small mammal species (19 species) have chigger mites on their body surface except 2 species, *Parascaptor leucurus* (Blyth, 1850) and *Mus musculus* Linnaeus, 1758. The total constituent ratio of 12 dominant small mammal species (with more than 60 individuals for each species) reach 95.46% while the rest 9 species reach only 4.54% (in the three differently oriented areas. Twenty-one species of small mammals were found in the southern area beside Erhai Lake (south site, S) and the species diversity is the highest among the three differently oriented areas. *E. miletus*, *A. chevrieri*, *R. norvegicus* and *R. nitidus* are so determined as four dominant species of small mammals in the south site and they account for 11.3%, 12.90%, 16.36% and 19.35% of the total respectively. However, only 13 species were found in the western area beside Erhai Lake (west site, W), where the dominant species are *E. miletus* (15.21%), *A. chevrieri* (21.00%) and *R. norvegicus* (19.38%). In the eastern area beside Erhai Lake (east site, E), 17 small mammal species were found and the dominant species are *E. miletus* (45.74%), *A. chevrieri* (12.94%), *M. pahari* (16.43%) and *R. norvegicus* (7.51%).

Table 2 Species diversity and community structure of chigger mites on small mammals

Main small mammal hosts	Code	*S*	*H'*	*J'*	*C'*	*Imt*	*Rmt* (%)
Anourosorex squamipes	1	20	2.1877	0.7303	0.1367	59.78	83.33
Suncus murinus	2	3	1.0609	0.9656	0.3580	0.15	5.00
Crocidura attenuata	3	13	2.0304	0.7930	0.1763	2.2273	28.79
Berylmys bowersi	4	14	1.1840	0.4487	0.3911	36.53	53.33
Mus caroli	5	2	0.3768	0.5436	0.7811	0.2667	6.67
Mus pahari	6	30	2.3995	0.7055	0.1297	2.0390	19.22
Micromys minutus	7	8	1.9796	0.9520	0.1474	0.5250	10.00
Rattus norvegicus	8	23	2.2009	0.7020	0.1831	0.8005	7.19
Rattus nitidus	9	15	1.5500	0.5724	0.3442	1.4263	6.37
Rattus tanezumi (= *R. flavipectus*)	10	3	0.9159	0.2779	0.4650	0.1339	2.07
Rattus steini (= *R. rattus sladeni*)	11	34	2.5852	0.7331	0.1139	11.7272	46.59
Apodemus chevrieri	12	48	2.5725	0.6645	0.1569	7.2464	39.63
Eothenomys miletus	13	51	2.3345	0.5938	0.1451	32.8046	61.13
Niviventer confucianus	14	31	1.5620	0.4549	0.4493	12.0449	33.71
Niviventer fulvescens	15	23	1.7593	0.5611	0.2892	34	63.64
Callosciurus erythraeus	16	3	0.9557	0.8699	0.4285	1	28.57
Dremomys pernyi	17	31	1.0997	0.3202	0.5675	93.43	81.54
Tupaia belangeri	18	58	2.2421	0.5522	0.1696	90.5737	83.61
Mustela kathiah	19	2	0.3046	0.4395	0.8347	5.5	100.00

The 56 895 chigger mite individuals were collected from the body surface of the corresponding small mammal hosts and are identified as 3 subfamilies, 13 genera and 109 species. Twenty-seven species of dominant chigger mites (more than 210 individuals for each) are the most abundant, accounting for 96.6% of the total chigger mites individuals in all three differently oriented areas, while the remaining 82 mites species only account for 3.4% of the total. Ninety-four species of chigger mites were collected from the southern area beside Erhai Lake with the highest species diversity in comparison with the other two oriented areas of Erhai Lake. *Leptotrombidium yui*, *Leptotrombidium eothenomydis*, *Leptotrombidium scutellare and Leptotrombidium parapalpale* are dominant chigger mite species from indoor habitats, cultivated fields, shrub areas to forest in the southern area beside Erhai Lake. However, the eastern area beside Erhai Lake has the lower species diversity with only 47 species of chigger mites collected. *Helenicula simena* is the dominant chigger mite species in indoor habitats and forest of the eastern area beside Erhai Lake, *L. scutellare* is the

dominant chigger mite species in cultivated field, Leptotrombidium sinicum is the dominant species in shrub areas. In the western area beside Erhai Lake, 28 chigger mite species were found and *Ascoschoengastia rattinorvegici* is the dominant chigger mite species in indoor habitats, while *H. simena* is the dominant species in other three habitats (Table 3).

Table 3 Distribution of small mammal hosts and chigger mites in different habitats

Region	Number of species/individuals of chigger mites	Number of species/individuals of small mammals	Dominant chigger mite	Dominant host
Eastern area beside Erhai Lake	47(21 418)	17(1 491)	*Leptotrombidium sinicum*	*Eothenomys miletus*
Indoor habitats	2(6)	5 (178)	*Helenicula simena*	*Rattus norvegicus*
Cultivated fields	16(3 045)	10 (223)	*L. scutellare*	*E. miletus*
Shrub areas	28(8 027)	12(332)	*L. sinicum*	*E. miletus*
Forest	37(10 340)	10(758)	*H. simena*	*E. miletus*
Southern area beside Erhai Lake	94(33 858)	21(1 070)	*L. scutellare*	*Rattus nitidus*
Indoor habitats	8(85)	5(238)	*L. yui*	*R. norvegicus*
Cultivated fields	9(188)	7(228)	*L. eothenomydis*	*R. nitidus*
Shrub areas	43(10 105)	12(181)	*L. scutellare*	*E. miletus*
Forest	83(23 480)	14(423)	*L. parapalpale*	*Tupaia belange*
Western area beside Erhai Lake	28(1 619)	13(742)	*H. simena*	*Apodemus chevrieri*
Indoor habitats	11(230)	4(209)	*Ascoschoengastia rattinorvegici*	*R. norvegicus*
Cultivated fields	13(166)	8(200)	*H. simena*	*E. miletus*
Shrub areas	20(667)	10(228)	*H. simena*	*A. chevrieri*
Forest	14(556)	9(105)	*H. simena*	*A. chevrieri*

The distribution of chigger mites and their corresponding hosts are quite uneven within different habitats in differently oriented areas. The species of small mammals and chigger mites show a gradually increasing tendency from indoor habitat, cultivated fields, and shrub areas to forest. This may imply that ecological environment influences the species composition and distribution of chigger mites and their corresponding hosts. Since the investigated sites were chosen in different landscapes within the same geographical zone where the longitude, latitude and altitude are very similar and Erhai Lake forms a natural (inartificial) isolation barrier, geographical location should not be the major factor of influencing the species diversity and distribution of chigger mites. As the vary circumstances, habitats, temperatures and precipitations vary, they should be the major ecological factors influencing the distribution of chigger mites and their small mammal hosts. Our study results also showed that the abundance, distribution and diversity of chigger mite vary among different populations of host species and habitat. In some host-parasite associations, much of the variation seems to depend on the identity of the host species, whereas in other cases it is better explained by local environmental conditions. Chigger mites (only the larvae are ectoparasites) spent a considerable time off host and are strongly affected by the off-host environment (temperature, precipitation and habitat where they lived in, since average annual temperature variation of the three sites is small (0.1 ℃) (30 years of 1976 – 2006), precipitation and habitat are the major ecological factors influencing the distribution of chigger mites (Table 1).

3.3 Similarity comparison of 27 dominant chigger mites on 19 species small mammals

The dendrogram of hierarchical cluster analysis show that the similarity of chigger mite communities is not highly consistent with the affinity of small mammal hosts in taxonomy. Some clustered groups in the dendrogram seem to be slightly consistent with the affinity of small mammal hosts on the taxonomic level of "family", but not on the level of "genus": (1) *R. steini*, *N. confucianus* and *A. chevrieri* in three genera (not the same genus) of family Muridae in zoological taxonomy are clustered into a group in the dendrogram; (2) *R. norvegicus*, *R. nitidus* and *M. pahari* in two genera (not the same genus) of family Muridae are clustered into a group. The two examples reveal that some chigger mite communities on the same family of small mammal hosts would tend to be similar with the same or similar dominant chigger mite species. The similarity and clustered result of some more chigger communities, however, do not show a consistency with the taxonomic affinity of small mammal hosts: (1)The

chigger mite communities on *S. murinus* (order Insectivora), *R. tanezum* (genus *Rattus* in order Rodentia), *M. caroli* (genus *Mus* in order Rodentia) and *M. minutus* (genus *Micromys* in orders Rodentia) merge into the same group though the small mammal hosts belonging to different genera, families and even orders; (2) *C. attenuata* (order Insectivora) and *C. erythraeus* (order Rodentia) do not belong to the same orders in zoological taxonomy, but the chigger communities on their body surface merge into the same group; (3) *E. miletus* (family Cricetidae) and *N. fulvescens* (family Muridae) are not in the same family, but merge into the same group; (4) *A. squamipes* (order Insectivora) and *T. belangeri* (order Scandentia) are not in the same orders, but merge into the same group. The similar habitat selection of the small mammal hosts in different families and even orders may result in the above results. For example, *S. murinus*, *R. tanezum* and *M. caroli* are typical small mammal hosts found in indoors and the habitats nearby indoors with similar habitat selection, and this might explain why the chigger mite communities on their body surface tend to be similar and merge into the same group. *E. miletus* and *N. fulvescens* are typical wild rodents and they are often found in the same wild habitats, and this may be a reasonable explanation for the similar chigger communities on them. All the above results suggest that the similarity of chigger mite communities is not highly consistent with the affinity of small mammal hosts in taxonomy, but is strongly influenced by the habitats where the small mammal hosts live.

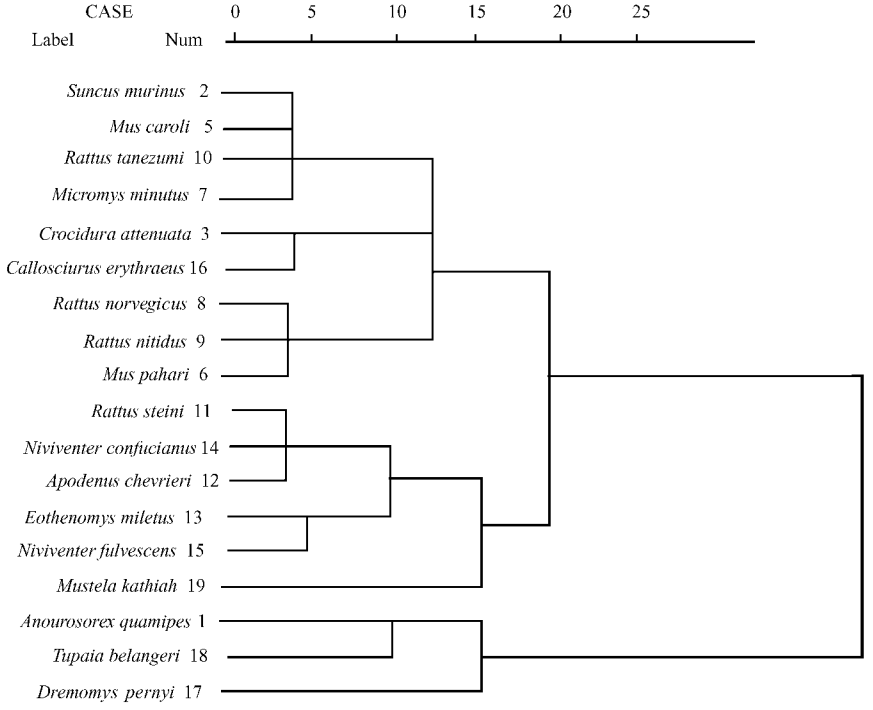

Fig. 1　Hierachical cluster dendrogram of dominant chigger mite communities on 19 species of small mammal hosts in the surrounding areas of Erhai Lake in Dali, Yunnan

Rattus tanezumi = *R. flavipectus*; *Rattus steini* = *R. rattus sladeni*.

3.4　Niche breadth and host specificity of chigger mites

As ectoparasites on the body surface of small mammals, chiggers have to suck body fluid or even blood from their hosts as their nutrition sources. From this point of view, small mammal hosts could be considered as the food resources of chiggers. In our study, small mammal hosts are actually regarded as trophic resource series (food resource series). From the ecological point of view, the niche breadth reflects the host-specificity of chigger mites (the larger the value, the lower the specificity). The 27 actual niche breadths are arranged in a sequence from smaller to larger values, which reveals the following sequences of the host-specificity of the chigger mites from high to low: *L. shuqui*, *H. hastoclavus*, *L. parapalpale*, *L. sinicum*, …, *L. suense* (Table 4). Among all the chigger mites, the host-specificity of *L. suense*, *L. bishanense* and *G. lingguipelta* proves to be the lowest with a wide niche breadth on their hosts, and that of *L. shuqui*, *H. hastoclavus* and *L. parapalpale* are the highest with a narrow niche breadth (Table 4).

Table 4 Niche breadths and host-specificity of chigger mites

Species of chigger mites	Code	Number of individuals	Host range		Niche breadth	Sequence of host-specificity
			Value	Sequence		
Leptotrombidium bambicola	1	407	11	7	0.2203	6
L. bishanense	2	250	9	5	77.1028	25
L. deliense	3	221	8	4	10.4025	21
L. densipunctatum	4	1 361	11	7	7.5996	19
L. eothenomydis	5	3 647	13	9	0.3260	8
L. fujianense	6	218	4	1	0.5901	9
L. gongshanense	7	419	7	3	1.3049	13
L. liemalis	8	754	9	5	1.4119	14
L. jinmai	9	771	8	4	29.7611	23
L. longimedium	10	458	7	2	1.4219	15
L. parapalpale	11	4 560	6	2	0.0540	2
L. rusticum	12	2 364	13	9	0.8232	10
L. scutellare	13	10 771	15	10	0.0868	5
L. shuqui	14	2 858	11	6	0.0538	1
L. sinicum	15	9 971	16	10	0.0691	3
L. suense	16	216	10	6	79.9874	26
L. xiangguanense	17	272	7	3	9.8634	20
L. xiaowei	18	259	7	3	1.0674	11
L. yongshengense	19	1 460	4	1	2.8333	16
L. yui	20	1 473	10	6	4.3787	17
Trombiculindus yunnanus	21	1 319	6	2	5.2920	18
Helenicula simena	22	5 044	13	9	0.3225	7
Herpetacarus hastoclavus	23	2 492	12	8	0.0538	1
Walchia ewingi	24	1 283	7	3	0.0728	4
W. koi	25	600	9	5	25.6037	22
Gahrliepia lingguipelta	26	975	4	1	41.7266	24
G. yunnanensis	27	535	6	2	1.1979	12

4 DISCUSSION

4.1 The species diversity, abundance and community structure of chigger mites

We captured 3 303 small mammals in the investigated sites and collected 56 895 chigger mite individuals, which belong to 109 species. Our study shows that the species diversity of chigger mites on small mammals is very high (109 species) and the community diversity indices (Shannon-Wiener's diversity indices) of chigger mites on most small mammals are beyond 1 (high), which was similar to Hou's report (Hou *et al.*, 2006). Most small mammals can parasitize more than two species of chigger mites on their body surface. The mite infestation rate and mite index are two important parameters reflecting the prevalence and intensity of chigger infestations. Our investigations have shown that chigger mites are very common on small mammals. The prevalence and intensity of chigger mites on small mammals are usually quite high. Guo *et al.* (2004) once made an investigation on fleas, gamasid mites and sucking lice in more than 17 counties in Yunnan Province, but did not collect more than 109 species like our investigation on chigger mites. The investigated sites in this study are strictly confined to the surrounding areas in Dali of Yunnan, but the chigger species have reached 109 species (very abundance). In comparison with the related reports from other ectoparasites (sucking lice, fleas and gamasid mites, *etc*), our investigation shows that the species diversity of chigger mites in a certain region or on a certain host is much higher than that of other ectoparasites (Guo *et al.*, 2004; Guo *et al.*, 2000; Meng *et al.*, 2007; Luo *et al.*, 2007; Hou *et al.*, 2006). Zhang *et al.* (2008) once collected 15 773 fleas from 21 counties in Yunnan Province, which were identified into 7 flamilies, 34 genera and 86 species. Guo once collected 68 571 gamasid mites from 25 counties in Yunnan Province, which belong to 9 families, 29 genera, 52 species (Luo *et al.*, 2007). Hou *et al.* (2006) once collected 3 subfamilies, 21 genera, 192 species 87 416 chigger mites from 16 counties in Yunnan Province. Our study shows that the species diversity of chigger mites on small mammals is very high (109 species) in the investigated sites.

4.2 Ecological relationship between chigger mites and their hosts

The reports from Men *et al*. (2007) showed that sucking lice have a high host-specificity with few species. Our investigation reveals that chigger mites are very common on the body surface of small mammals with abundant species and individuals. One species of small mammal host can harbor several species of chigger species at the same time while a certain species of chigger mite can simultaneously choose several species of small mammals as its hosts as well. The host-specificity of chigger mites is very low with relatively wide ecological niche in comparison with other ectoparasites. The similarity of chigger mite communities on small mammals is not highly consistent with the taxonomic affinities of corresponding small mammal hosts. The community structure of chigger communities are highly influenced by the habitats where small mammal hosts live and the related ecological factors such as temperature and precipitation, *etc*. The co-evolution between chigger mites and small mammal hosts has not reached a high level like sucking lice.

The dendrogram shows that the similarity of chigger mite communities is not highly consistent with the affinity of small mammal hosts in taxonomy. For example: (1) *Rattus steini*, *Niviveniе confucianus* and *Apodemus chevrieri* of the same family in taxonomy are clustered together in the same group in the dendrogram; (2) *Rattus norvegicus*, *Rattus nitidus* and *Mus pahari* of the same family in taxonomy are clustered together in the same group in the dendrogram, Foresaid two examples reveal that some chigger mite communities on the same family of small mammal hosts in taxonomy are classified into the same group with a high similarity in hierarchical cluster analysis. When the hosts have a close affinity, the chigger mite communities on their body surface would tend to be similar with the same or similar dominant chigger mite species. This might be an ecological evidence of co-evolution between small mammals and chigger mites.

However some more chigger mite communities were not consistent with the taxonomic affinities of their corresponding hosts in the dendrogram. Such as (1)the chigger mite communities on *S. murinus*, *R. tanezum*, *M. caroli* and *M. minutus* are not the same family, but merge into the same group; (2) *C. attenuate* and *C. erythraeus* are not the same family, but merge into the same group; (3) *E. miletus* and *N. fulvescens* are not the same family, but merge into the same group; (4) *A. squamipes* and *T. belangeri* are not the same family, but merge into the same group. The reason for (2), (3) and (4) were clustered that habitats of some hosts are similar. The results suggest that the types of chigger mite communities on small mammals are influenced by the habitats in which the hosts live. But not only (1) are not the same family but also habitats of some hosts are nor similar, but merge into the same group, the results reveal also that similarities of chigger mite communities were affected by other ecological factors (temperature, precipitation and humidity). the dendrogram of hierarchical cluster analysis will have to compare chigger mites with gamasid mites and shows that the similarity of chigger mite communities is not highly consistent with the affinity of small mammal hosts in taxonomy. Some clustered groups in the dendrogram seem to be slightly consistent with the affinity of small mammal hosts at the taxonomic level of "family", but not at the level of "genus". gamasid mites clustered groups in the dendrogram seem to be higher consistent with the affinity of small mammal hosts than chigger mites at the taxonomic level of "genus" (Dong *et al*., 2008).

No chigger mites are collected from 2 species of small mammals. It may result from less sampling numbers since the captured number of *P. leucurus* (2 individuals) and *M. musculus* (15 individuals) are not enough in the paper, It may be a natural phenomenon that no chigger mites or few chigger mites parasitize on the body surface of *P. leucurus* (2 individuals) and *M. musculus* (15 individuals).

4.3 Distribution of chigger mites and their corresponding hosts in different landscapes in the same zone

The results of the study reveal that the distribution of chigger mites and their corresponding hosts in three differently oriented areas beside Erhai Lake is different from each other. More species of chigger mites and their corresponding small mammal hosts were found in the southern area beside Erhai Lake than in other two oriented areas. In addition, a few more dominant chigger mite species and dominant small mammal hosts were also collected from the southern area beside Erhai Lake than in other two oriented areas. *E. miletus*, *A. chevrieri*, *R. norvegicus* and *R. nitidus* are determined as four dominant species of small mammals in southern area beside Erhai Lake and their constituent ratios account for 11.3%, 12.90%, 16.36% and 19.35% of the total respectively. *L. yui*, *L. eothenomydis*, *L. scutellare* and *L. parapalpale* are dominant chigger mite species from indoor habitats, cultivated fields, shrub areas to forest in southern area beside Erhai Lake with 3.69%, 10.74%, 18.01% and 13.47% of constituent ratios respectively.

Table 3 showed that the richness and diversity of small mammals influence the richness and diversity of chigger mites. The gradient change tendency of

community parameters in chigger mite community is in accordance with that in small mammal community in different habitats. This might be an ecological evidence of co-evolution between small mammals and chigger mites. Complicated habitats give rise to the high diversity of small mammals and chigger mites. Adler (1985) suggested that habitat selection is an important determinant factor in small mammal communities. Ecke *et al*. (2002) found that the cover of tall vegetation in the field layer and the structural heterogeneity positively influenced species richness. Most studies showed a positive correlation between habitat heterogeneity, diversity and small mammal species diversity. Our investigation sites were selected in three differently oriented areas beside Erhai Lake. The three regions formed different landscapes in the same zone where the longitude, latitude and altitude are very similar and Erhai Lake forms a natural barrier's isolation. The southern area beside Erhai Lake is located in the protection areas with a good coverage of ground vegetations, where the abundance and species richness of grasses and shrubs are higher than the other two oriented areas. This may influence the distribution of small mammal species. In addition, the boundary effect of transitional fauna or flora may be also an important factor on the small mammal distribution. The southern area beside Erhai Lake is the transitional region of Southern Ailao Mountain and Western Cangshan Mountain. The edge effect indicates that the richness and diversity of biology are more abundant in zoological interleaving zone than contiguous ecosystem. The edge effect may explain that more species of chigger mites and their corresponding small mammal hosts were found in the southern areas beside Erhai Lake than in the other two oriented areas.

Strong environment effects were also observed. Chigger mites have a complex life cycle with seven stages (eggs, prelarvae, larvae, nymphochrysalis, nymphs, imagochrysalis and adults), but only the larvae are ectoparasites (Li, 1997). Chigger mites spent a considerable time off host and are strongly affected by the off-host environment (temperature, precipitation and habitat). Li (1997) once investigated that environment factors (temperature, precipitation and habitat) were positively correlated with one or more parameters of chigger mites assemblages. Average annual temperature is 15.2℃ and the average precipitation is 1 026.8 mm in the southern area beside Erhai Lake and the climate factors in the southern area beside Erhai Lake may benefit chigger mites.

4.4 Relationship between niche breadth and specificity

A niche breadth could be simply defined as the resource-utilizing scope of a species in a certain community, which has an inverse relationship to the host-specificity of ectoparasites such as fleas, lice, ticks, gamasid mites and some mites when the resource-series is formed by hosts (Guo, 1998). The "host range" (the number of host species parasitized by ectoparasites) could reflect the host-specificity in some degree (Guo *et al*., 1993; Guo *et al*., 1999), but it only deals with one side of the specificity (the number of host species) and does not consider the other side, the number of individual ectoparasites like chigger mites on each species of host. The host range alone is not very effective in evaluating the host-specificity of ectoparasites. In Levins' niche breadth, however, both aspects of the specificity are taken into account. A larger niche breadth means lower host-specificity. A low host-specificity further implies that chigger mites have not highly adapted to the body surface of small mammals. By using the niche breadth of chigger mites, host-specificity of chigger mites are low and this may imply that the degree of co-evolution between small mammals and chigger mites is not high. The above ecological characteristics of chigger mites also signify to strengthen the chigger mites' potential ability of transmitting some mite born diseases among different small mammal hosts.

In conclusion, the paper investigated the species diversity, abundance, community structure, similarity, distribution and niche of 56 895 chigger mites on 3 303 small mammals in the surrounding areas of Erhai Lake. The abundance and diversity of chigger mite vary among different populations of host species and habitats. The distribution of chigger mites and their corresponding hosts are quite uneven in differently oriented areas. This may imply that ecological environment influences the species composition, distribution of chigger mites and their corresponding hosts. The similarity of chigger mite communities is not highly consistent with the affinity of small mammal hosts in taxonomy and host specificity of chigger mites is very low. This may imply that the degree of co-evolution between small mammals and chigger mites has not reached a high level. This suggests that the types of chigger mite communities on small mammals are influenced not only by their hosts but also by ecological factors (habitats where hosts live, temperature and precipitation). The above ecological characteristics of chigger mites also signify to strengthen the chigger mites' potential ability of transmitting some mite born diseases among different small mammal hosts.

ACKNOWLEDGMENTS We thank some of our colleagues and college students for their help in the field investigation. The project was funded by National Natural Science Foundation of China (Grant No. 30460125).

References

Adler GH, 1985. Habitat selection and species interaction: An experimental analysis with small mammal population. *Oikos*, 45: 380 – 390.

Dong WG, Guo XG, Men XY, Qian TJ, Wu D, 2008. Diversity of gamasid mites on small mammals in the areas of Erhai Lake in Yunnan, China. *Acta Entomologica Sinica*, 51(11): 1 177 – 1 186. [董文鸽, 郭宪国, 门兴元, 钱体军, 吴滇, 2008. 中国云南洱海周边小兽体表革螨多样性. 昆虫学报, 51(11): 1 177 – 1 186]

Durden LA, 1992. Parasitic arthropods of sympatric meadow voles and white-footed mice at Fort Detrick, Maryland. *Journal of Medical Entomology*, 29(5): 761 – 766.

Ecke F, Lögren O, Sorlin D, 2002. Population dynamics of small mammals in relation to forest age and structural habitat factors in northern Sweden. *J. Apply. Ecol.*, 39: 781 – 792.

Guo TY, Xu RM, Liu GP, 2002. Study on chigger mite communities of the rodent in dongling mountain in Beijing. *Chinese Journal of Vector Biology and Control*, 13(3): 176 – 177. [郭天宇, 许荣满, 刘国平, 2002. 北京东灵山地区鼠类体外寄生恙螨群落的研究. 中国媒介生物学及控制杂志, 13(3): 176 – 177]

Guo XG, Qian TJ, Guo LJ, Wang J, Dong WG, Zhang L, Ma ZM, Li W, 2004. Species diversity and community structure of sucking lice in Yunnan, China. *Entomologia Sinica*, 11(1): 61 – 70.

Guo XG, Qian TJ, Men XY, Dong WG, Shi WX, Wu D, 2006. Preliminary analysis of chigger communities associated with house rats (*Rattus flavipectus*) from six counties in Yunnan, China. *Systematic and Applied Acarology*, 11: 13 – 21.

Guo XG, Shen LJ, Yang YM, Huang XQ, 1993. A research on the distribution and interspecific association of gamasides. *Journal of Dali Medical College*, 2(4): 7 – 11. [郭宪国, 申丽洁, 杨毅梅, 黄秀琼, 1993. 几种主要鼠形小兽体表革螨分布及种间协调关系研究. 大理学院学报, 2(4): 7 – 11]

Guo XG, Gong ZD, Qian TJ, Feng XG, Duan XD, Li W, Zhang XK, 1999. Host-specificity and host-selection of fleas in foci of human plague in Yunnan, China. *Entomologia Sinica*, 6(4): 370 – 377.

Guo XG, Gong ZD, Qian TJ, Feng XG, Duan XD, Li W, Zhang XK, 2000. The comparison between flea communities on the species of small mammals in the foci of human plague in Yunnan, China. *Entomologia Sinica*, 7(2): 169 – 177.

Guo XG, 1998. Host-specificity and host-selection of gamasid mites (Acari: Gamasina). *Systematic and Applied Acarology*, 3: 29 – 34.

Guo XG, Ye BH, Gu YM, Chen YM, 1996. Studies on the similarity and classification of gamasid mite communities on small mammals in the west of Yunnan province. *Chinese Journal of Parasitology & Parasitic Diseases*, 14(1): 42 – 45. [郭宪国, 叶柄辉, 顾以铭, 陈渊民, 1966. 云南西部小兽革螨群落相似性及分类研究. 中国寄生虫学与寄生虫病杂志, 14(1): 746 – 751]

Hou SX, Guo XG, Men XY, Qian TJ, Wu D, Shi WX, 2006. Study on the fauna and vertical distribution of chiggers in Yunnan. *Acta Zootaxonomica Sinica*, 31(4): 746 – 751. [侯舒心, 郭宪国, 门兴元, 钱体军, 吴滇, 石武祥, 2006. 云南省恙螨区系及垂直分布研究. 动物分类学报, 31(4): 746 – 751]

Li JC, 1997. Trombiculid Mites of China: Studies on Vector and Pathogen of Tsutsugamushi Disease. Guangdong Science and Technology Press, Guangzhou. 570 pp. [黎家灿, 1997. 中国恙螨, 恙虫病媒介与病原体研究. 广州: 广东科技出版社. 570 页]

Liu YX, Zhao ZT, Wu QY, Meng XR, Xue J, Yang ZQ, 2004. Community structure of chigger mites parasitic on small rodents and insectivores in Shandong Province. *Chinese Journal of Zoology*, 39(2): 62 – 65. [刘运喜, 赵仲堂, 吴钦永, 孟祥瑞, 薛健, 杨占清, 2004. 山东部分地区小兽类寄生恙螨的群落结构. 动物学杂志, 39(2): 62 – 65]

Lu WD, Wu XZ, 2006. SPSS for Windows. 3rd ed. Publishing House of Electronics Industry, Beijing. 700 pp. [卢纹岱, 吴喜之, 2006 SPSS for Windows 统计分析 (第 3 版). 北京: 电子工业出版社. 700 页]

Luo LP, Guo XG, Qian TJ, Wu D, Men XY, Dong WG, 2007. Distribution of gamasid mites on small mammals in Yunnan, China. *Insect Science*, 14: 71 – 78.

Men XY, Guo XG, Dong WG, Niu AQ, Qian TJ, Wu D, 2007. Ectoparasites of Chevrier's field mouse, *Apodemus chevrieri*, in a focus of plague in southwest China. *Medical and Veterinary Entomology*, 10: 1 – 4.

Pung OJ, Durden LA, Banks CW, Jones DN, 1994. Ectoparasites of opossums and raccoons in southeastern Georgia. *Journal of Medical Entomology*, 31(6): 915 – 919.

Saxena VK, 1989. Chigger mite infestation of small mammals in a feral biotope of public park area of south Delhi. *Journal of Communicable Disease*, 21(4): 360 – 364.

Weider LJ, 1993. Niche overlap and the potential for competition and intraguid predation between size-structureed populations. *Ecology*, 73(4): 1 431 – 1 444.

Wu GH, Zhang Y, Guo HB, Jiang KJ, Zhang JJ, 1996. The role of *Leptotrombidium scutellare* in the transmission of human diseases. *Chinese Journal of Preventive Medicine*, 30(3): 133 – 135. [吴光华, 张云, 郭恒彬, 姜克检, 张家驹, 1996. 小盾纤恙螨在传播人类疾病中的作用. 中华预防医学杂志, 30(3): 133 – 135]

Wu GH, Zhang Y, Guo HB, 2004. Study on the transovarian transmission of pathogen in *Leptrombidium scutellare*. *Chinese Journal of Vector Biology and Control*, 15(4): 301 – 303. [吴光华, 张云, 郭恒彬, 2004. 小盾纤恙螨经卵传递病原体研究. 中国媒介生物学及控制杂志, 15(4): 301 – 303]

Zhang SY, Guo XG, Gong ZD, Zhang LY, Wu D, Wang ZK, 2008. Investigation on community ecology and species-abundance distribution of fleas on small mammals in 21 counties of Yunnan, China. *Chinese Journal of Zoonoses*, 24(6): 518 – 521. [张胜勇, 郭宪国, 龚正达, 张丽云, 吴滇, 王政昆, 2008. 云南省 21 县市小兽体表蚤类群落生态及种多度分布. 中国人兽共患病学报, 24(6): 518 – 521]

(责任编辑: 袁德成)

中国云南洱海周边小兽体表恙螨多样性

董文鸽[1]，郭宪国[1,*]，门兴元[2]，钱体军[1]，吴　滇[1]

（1. 大理学院病原与媒介生物研究所，云南大理　671000；2. 山东省农业科学院植物保护研究所，济南　250100）

摘要：本文运用 Shannon-Wiener，系统聚类分析方法（SPSS 13.0 软件）和 Levins' niche 等对云南大理洱海周边 3 303 头小兽体表寄生恙螨的物种多样性、群落结构、相似性、分布和生态位进行研究。调查点位于我国 11 大鼠疫自然疫源地之一，此地也是我国恙虫病和流行性出血热的流行地区。选择的洱海周边 3 个不同方位恰好处于东部无量山、南部哀老山和西部苍山，由于洱海的天然隔离使这 3 个方位形成了同地域（经度、纬度、海拔和动物地理区划相同）异生境的地理景观。从洱海的 3 个方位共计诱捕小兽 3 303 头，分类鉴定为 4 目，7 科，15 属，21 种。从小兽体表共计检获 56 895 头恙螨，分类鉴定为 3 亚科，13 属，109 种。恙螨的丰富度、分布和物种多样性随着宿主和生境的不同而存在着显著的差异。恙螨只有幼虫寄生，强烈受到环境（温度、降雨量和生境）的影响。恙螨的宿主特异性很低，恙螨的群落相似性大小与宿主小兽之间的近缘性高低呈现较低的关联度。结果提示，大部分的宿主小兽和恙螨之间协同进化程度不高；恙螨的这些特征从流行病学的角度来看，恙螨作为医学媒介生物在宿主之间传播疾病的潜能较大。

关键词：蜱螨亚纲；恙螨；小兽；同地域异生境；群落生态；协同进化；云南

中图分类号：Q968.1　　**文献标识码**：A　　**文章编号**：0454-6296（2008）12-1279-10